GASL – ACTION NETWORK
"RESTORING VALUE TO GRASSLAND"

Proceeding of the Workshop
Multifunctionality of pastoralism: linking global and local strategies through shared visions and methods

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SATTELITE WORKSHOP | INTERNATIONAL RANGELAND CONGRESS - July 16 & 17, 2016 - SASKATOON

How to cite the document:

Blanfort, V.; Lasseur, J.(eds), 2018. Multifunctionality of pastoralism: linking global and local strategies through shared visions and methods *in GASL Action network « Restoring value to grassland ». GASL, Montpellier, 127.p.*

Proceeding of the Workshop
Multifunctionality of pastoralism:
linking global and local strategies through shared visions and methods

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Conceptual models of livestock multi-functionality

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Why conceptual modeling

Describing the multi-functionality of livestock is recognizing that a system can be addressed from different perspectives. We are talking about a system as a coherent whole regarding a functioning, a global behavior or dynamics. In our case the livestock is not the system. The system is the set of components: livestock, actors of various kinds, biophysical elements, resources that are necessary to account a given function. But what is a function? Mathematically it is anything transforming something into something. We already mentioned a functioning, i.e. a well defined global dynamics. In our context, it is the service provided to an identified human community. Of course, this service can be more or less valued by the given community. An immediate consequence is that each function brings about (enacts) its own system, different for each function. It is these systems we intend to describe.

But what do we mean by describing? It can extend from oral or written discourse up to mathematical or computer models. Despite our effort to define (all?) the words we are using, and to use the same words consistently throughout our discourse, it is hard to extract from discourses what are the key concepts and capture their supposed relationships unless we are very familiar with the domain, i.e. both with what we are talking about, and the history of the choices made to describe it. On the other hand, mathematical and computer models appear to be very concise, capturing the essential matter. Unfortunately, they could also be hard to understand without a good literacy in mathematics and computer science. Therefore, the question becomes: does it exist a description able to expose the key concepts and their relationships that are neither texts or discourse, nor equations or code, and that could be understood with minimal literacy? We pretend that conceptual models are candidates for such descriptions. It remains to present what are models in general and conceptual models in particular. We will present a graphical representation that appeared usable for such matter as well as a methodology to build such representations. Finally, we will address the question of validation and articulation of the obtained perspectives.

What is a model?

Assuming we want to assess the sustainability of an ecosystem, called A (see figure 1, left). We can hardly manipulate a whole ecosystem to understand how it behaves in response to the variability of various factors (rain, temperature, etc.). If we hypothesize that the dynamics of the biomass is significant with respect to the sustainability of the system, we could try to record the observations over time (see figure 1, middle top). These observations could be fitted by a curve with an equation $y = f(x)$ where y is the quantity of biomass and x is the time. This process of choosing the dynamics to account for and the related kind of equation is called an *abstraction*. Given this equation, the choice of its parameters in order to fit the observed data is called a *calibration*. The calibrated equation becomes the model of the ecosystem through this particular abstraction (it could have been done otherwise). To increase the confidence on the model, we can also *evaluate* it. One way is to calibrate it on a subseries of observed data and

check whether the obtained model fits the other ones (see figure 1, middle bottom). Now, it is possible to manipulate the model like drawing it, building its derivatives, finding its maxima or minima and whether it becomes zero (see figure 1, right). This last property (becoming zero) can be *interpreted* as a breakdown of the ecosystem. Hence, the question of sustainability on the ecosystem becomes the question of becoming 0 on the model. If the model answer "no" (i.e. it never becomes zero), then the ecosystem can be interpreted as sustainable, as far as the evolution of the biomass is the right clue (see figure 1, bottom).

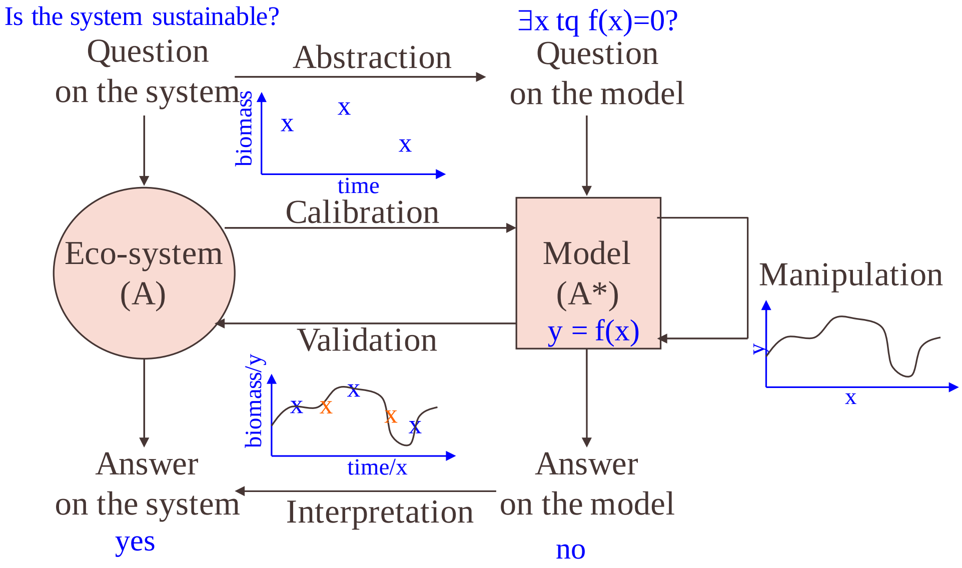

Figure 1. *how to relative a model to a system and conversely*

To sum up and following [Minsky65], any object A* (here the calibrated equation) is a model of a system A (here the ecosystem) if manipulating A* allows to answer some questions Q (is the ecosystem sustainable) asked by an observer X on the system A. It means that the observer X instead of manipulating A to get his answers will use another object A* sufficiently standing for A to provide valuable answers on A. This definition is very general because no hypotheses are made on the nature of the object A*. It can be a living animal (for example the drosophila to understand of laws of genetics), a living plant (like the rice for crop species), a mockup, a mathematical formula (like in our example) or a computer program. The main requested feature is its manipulability. Then, of course, A* is a description in the sense discussed earlier. But A* cannot be simply a text because a text can hardly be manipulated but by the intellectual thinking of the reader. However, it can be a mathematical formula through algebraic manipulation or a piece of computer code through running the program. A* will be called a representation to capture both its standing for something else (the system A) and its manipulability. A* must even be a formal representation, meaning that the manipulation depends on its form (e.g. $(A + B)*C \Rightarrow A*C + A*B$) independently of what it stands for (who knows what A, B and C are!). We can find the zeros of the equation $y = f(x)$ even if we do not know that y represents the biomass and x the time. Finally, we expect A* to capture everything that is necessary to answer the questions Q but only what is necessary to answer those questions. This principle of parsimony is very important because an exhaustive description of any system A could potentially be endless (and useless).

What is a conceptual model?

Let us focus on the abstraction going from a system towards a model. In our example, we have first identified the system to model, i.e. the ecosystem. It amounts to identify what is part of the system and what is not part of it, i.e. both its border and its extent. Therefore, talking about a system already is an abstraction. Second, we have chosen how to describe it. We could have enumerated its components and relationships among them and how to describe each component, being heterogeneous or not. Here it was chosen to characterize globally the ecosystem by a quantity. Moreover, sustainability deals with time: past and present because it still is…present, but also the future. Hence, we have the concepts of ecosystem, biomass and its measure of quantity, time, and maybe trajectory. These concepts are the components of the abstraction even before formulating a suitable equation. Because they are concepts, their representation is called a conceptual model.

Figure 2 illustrates that in between *x*, *y* and *f* being part of the model and the system to be modeled, the abstraction process is based on a number of concepts that are of outmost importance both for justifying the model and for interpreting the answers from the model. Moreover, everybody can potentially understand these concepts while not everybody is able to understand an equation or a piece of code. Therefore, the conceptual model appears central for multi-disciplinary understanding. It remains to explain what we mean by concept and how to represent them.

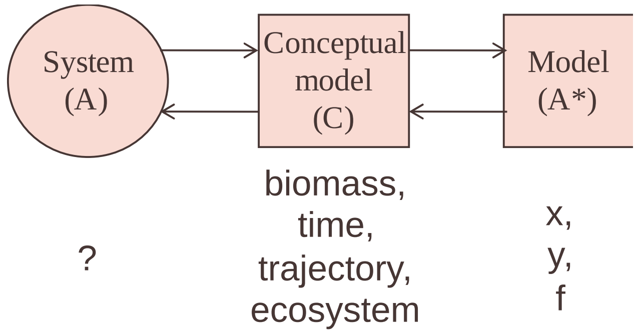

***Figure 2**. The conceptual model between the system and the model.*

What is a concept?

A concept is the idea one have in his mind of something. First of all, the idea is always one's idea. It is personal. This concept can be related to an individual objet: my concept of my car, my concept of the ecosystem I am interested in. It can be related to an immaterial object of thought: my concept of beauty, equity or of what a concept is. Finally, it can be a category, i.e. a way to put objects together: because they have the same size or color, because they are of the same species, etc. These concepts are called categorical concepts. They are the boxes used to classify the world. Of course, an object (or at least his idea) can be in several categories at ones (both big, blue and of a given species). These concepts build how the reality appears to us. One of the important process of everyday knowledge in general, and of science in particular, is first to create a world of distinctions: e.g. the mineral from the vegetal from the animal. And this world of distinction must be operative for making the reality understandable if not predictable.

How to represent a concept?

If a concept is something in one's mind, we have a problem because we are unable to look into one's mind nor do we know what is a mind. Fortunately, they appear through the words we are using. Even if we may not know what it means for someone to be blue, at least we know that he has a category of blue things called "blue things". There are very often labels onto the boxes. Therefore, the terminology is the (only?) entry point into one's mind. But how to be sure about the nature of the objects that are named? Especially, how to be sure that two observers are meaning the same object or category of objects when they use the same word. The only entry points we have are the definitions. A definition relates a word to a set of related other words. If the same word is not related to the same set of related concepts (not just words because they could also use different words for the same concepts), they are related to distinct concepts. Conversely if two different words are related to the same set of related concepts, then they are related to the same concept. Therefore, we obtain a network of related concepts (and associated words) where, additionally, the relations themselves are named (and therefore might be concepts as well). It is this network that we call a conceptual model. One of its property is to be closed, i.e. all the concepts necessary to define the other concepts of the same network are in the network OR the concept is considered atomic, i.e. not necessary to be explained further for our purpose. Therefore, any conceptual network defines its level of granularity, a kind of conceptual scale. For example, it might not be necessary to explain that an animal or plant is made of cells and atoms, nor how we make the distinction between plants and animals for describing an ecosystem. When the concepts are directly related to spatial or temporal concepts, the conceptual scale strictly corresponds to the usual concept (sic!) of scale with an extent and a granularity.

To represent such terminological and/or conceptual networks, a number of formalisms have been proposed like the formal logics or the frame languages, and more recently the description logics (DL), the ontology languages (OWL) and the thesaurus languages (SKOS). We have chosen to use a graphical representation to highlight the graph structure of the conceptual model, using UML (Unified Modeling Language). UML is mainly used by the computer scientists. Although UML does not provide the expressiveness we could expect from such formalisms.

UML introduces a number of diagrams from which the class diagram is the most suitable to graphically represent the concepts. The concepts are represented by a class made of a box with two parts: an upper part with the concept name (capitalized and singular) and a lower part with the list of attributes. In the figure 5 a), the concept of farmer is represented with three attributes: its name, age and height. The concepts are related to one another with a number of possible arrows:

- The line with a triangular white arrow to represent a generalization/specialization relationship to build taxonomies of concepts (in Figure 5 b), the concept of farmer is a specialization of the concept of person: every farmer is a person, but not the converse);
- The line with a white or black diamond to represent the part-of relationship (in Figure 5 c), a tree is a part of a forest, or a forest is made of trees);
- The simple line (although sometimes with arrows to denote a natural directionality) with a name to represent a relationship. It is annotated with cardinalities, i.e. how many objects of a category can be related to how many objects of the other (in Figure 5 d), there is an ownership relationship (or association) between the concept of farmer and the concept of plot, and a plot is owned by only one farmer (1) and the farmer can have as many plots as he wants (*)).

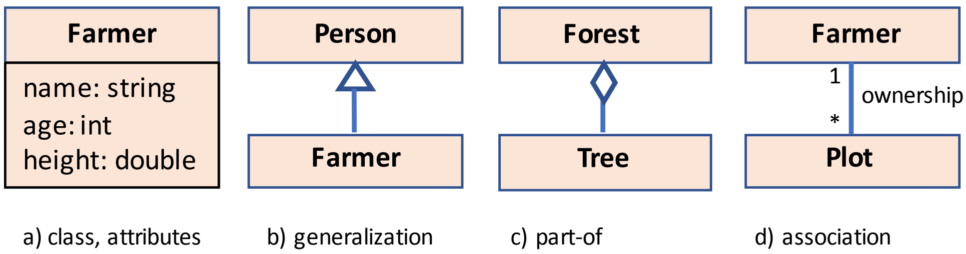

***Figure 3**. Some basic UML representations*

Using UML, a definition can be easily translated into a UML graph. For example, the Collins defines a livestock as being animals kept in a farm. A resulting graph could be as represented in the figure 4. The livestock is made of animals (or animals are part of livestock) and the livestock has a location relationship to the concept of farm (a livestock is only located on one farm that may have many livestocks). This formalism will be used throughout the rest of the chapter.

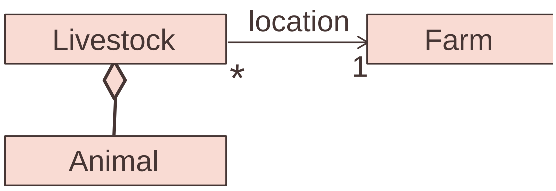

***Figure 4**. UML class diagram for a livestock definition*

Introducing multiple perspectives

The understanding and the modeling of socio-ecosystems organized around the livestock requires to convoke a set of disciplines. Effectively, to account for the biophysical dynamics impacted by the livestock, we need as well hydrography as soil sciences or ecology. And the social practices and dynamics require agronomy, economy, sociology, management sciences, etc. This necessary dialog among the disciplines raises a number of open issues. First, their interactions can raise new questions in each field. For example, classical hydrology, as well as ecology of the populations, are not really equipped with the necessary concepts to account for collecting. Then, in a modeling approach, the various disciplinary fields invest differently in the use of formalisms, especially mathematical ones. Finally, the terminology and the associated concepts are strongly heterogeneous among the disciplines and, sometimes, within a single discipline depending on the school of thought and the questions raised. It possibly (if not always) creates misunderstanding that hinders the construction of an integrated model of socio-ecosystems. This multiplicity of points of view raises the question: "how to represent and to integrate the knowledge of heterogeneous disciplines in the same model?".
But the social systems we are seeking to model are themselves made of a multiplicity of organization levels (more or less structured social networks, epistemic communities or communities of practice, customary organizations,

associations, state services, administrative units, etc.). The levels themselves induce different points of view that account for the observed behaviors. It is because one view an animal as a livestock that one breeds it. In general, the same object will be viewed differently depending on the envisaged interactions or uses, and named differently. Hence a person will be seen as a citizen from the point of view of the state, an inhabitant by a commune, a member of an association, the father or the mother of the family. Each of the point of view or role is associated with very different expected relations, behaviors, rights and duties. For the objects, a tree can be seen as a protected species for international or national laws, a stock of carbon, the nest of some birds, and providing good construction wood for local communities. In general, an object can be seen as a resource as long as it can possibly be used by someone. It is the same for the space that can be appropriated differently by different groups of people (the so-called territories in the French sense) or other living beings (the so-called habitats) and different uses. It creates a set of superposed mosaics shaping the landscape.

These points of view are different because the disciplinary points of view are points of view on the system, while the others are points of view within the system. However, they are all points of view to be articulated to one another to account for the complexity of the socio-ecosystem under study. Moreover, a discipline exists through a group of people permanently debating about a set of shared concepts to account for their object of science (and debating about what this object of science is). Then, a point of view is always socially built regardless of being outside or inside the system. Finally, a point of view is always a subset of the concepts built by a group (or several groups) of people focused on the objective to be tackled, being practical or scientific.

Methods

There are several methods to obtain a conceptual model:

- By manual or automatic extraction from a text (or corpus);
- By derivation from the formulation of the objective/question originating the point of view;
- By interview with the concerned actor (knowledge engineering);
- By collective animation

Extraction from a text

A text is organized with common nouns, adjectives and verbs articulated by prepositions determining composition (of), and temporal and spatial situations. The proper nouns directly correspond to individual concepts. The verbs of action articulate their subjects (who is performing the action), objects (on what), means (using what), results and spatial and temporal modalities (when and where). The state verbs generally define relations or definitions (to be). The adjectives suggest the attributes of which they are a possible value (the sky is blue => attribute “color” of which one possible value is “blue”).

Manually, underlying each common noun, verbs (distinguishing state and action verbs) and adjectives allows to extract a starting list of words to account for and to organize depending on the sentence structure. One must care of the concepts corresponding to composed words (e.g. flower plant or European union), to consider therefore as a single word!

Automatically, some software exists to extract key-words from texts, more or less correctly (e.g. eliminating the articles, prepositions and structuring words). Of course, it is only a starting base for further work. It is better to choose software that realize a real grammatical analysis of the sentences, possibly generating partial graphs (or even complete graphs).

Derivation from a question

Because we have to represent the concepts used from a particular point of view, we can start from a statement of the problematics/question/objective justifying this point of view. First, one must write down the question in a sentence as complete as possible, and then take each word and define it until we come up with a complete (closed) graph. The advantage is that we obtain a very focused conceptual model. It helps to obtain all that is necessary but only what is necessary to understand and answer the question.

To illustrate this approach, let's take the following question (Müller and Diallo 2012) :
« Given the residential segregation within a town, what is the impact of the student choices, of the strategy of the school directors and the scholar policy on scholar segregation?"
You favor the questions of the form « What is the impact of *X* on *Y*, given *Z* ? » to have the key elements of the question :

- *Z*: the fixed conditions;
- *X*: the drivers and/or possible choices on which the scenarios rely;
- *Y*: the indicators or outcomes we expect.

A possible result from the previous question asked to a geographer is shown in the figure 5.

In the higher part of the figure 5, we have the representation of the question around the asked person. The subgraph can be read: the geographer defines the residential segregation and observes the scholar segregation as a function of the strategies and policies. The rest of the graph defines the terms. For example, residential segregation is defined on a residential space made of zones, themselves made of places, each zone being characterized by its social category: poor, rich or medium. Any subgraph can be read as a similar sentence, revealing the options taken for addressing the question.

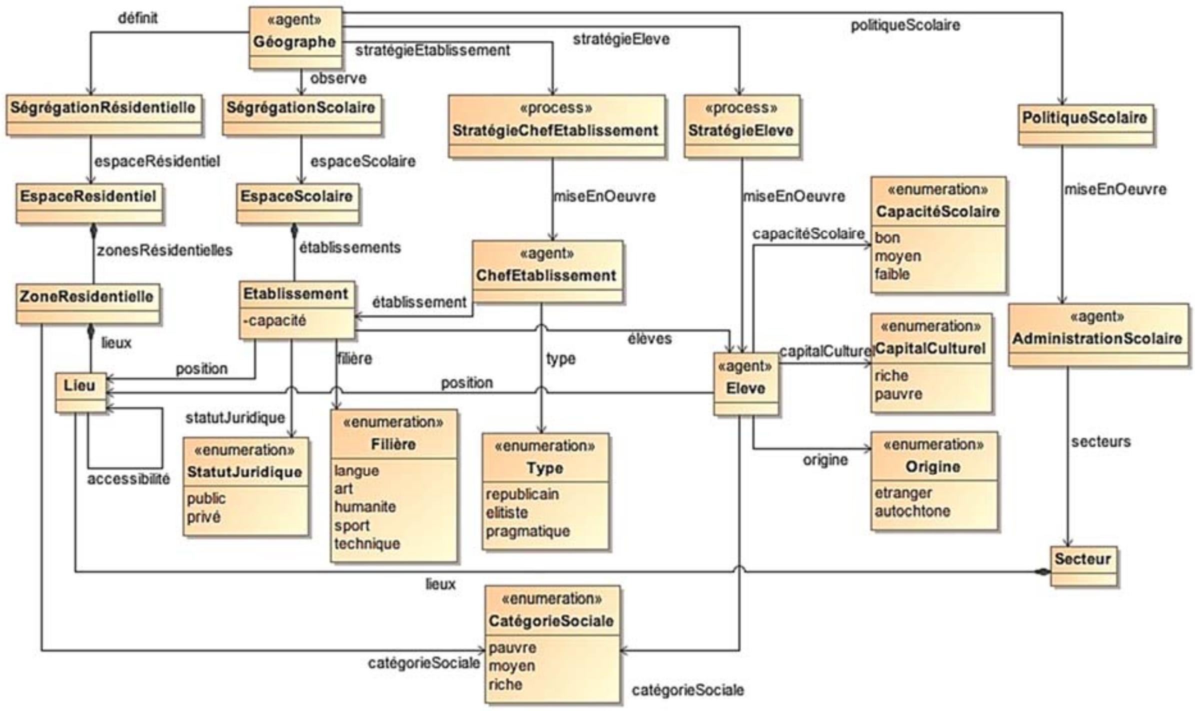

***Figure 5**. UML class diagram for a question on segregation*

Interview

To build a conceptual model from an interview still remains an art but the following questions can be used as a framework:

- Who are you? Disciplinary background and in the related project;
- What is your research question or your aim/objective? This allows to use the previous method with him;
- What is your research object? What are you looking at or managing? This allows to identify the system, i.e. to draw the border between the object of study and the rest (spatial and temporal limits, identity, composition, etc.)
- What are the activities you deploy to answer your question, manage your system? For each activity we must identify what they need (the resources), what they produce (products, knowledge, changes) and what is relevant to specify the activity.
- Are there other actors in your system under study/management or are there actors influencing the system? It

- is the departure point for reiterating the questions on each of those identified actors.

For example, the interview of a geneticist in the framework of domesticating a wild species gave the schema of the figure 6.

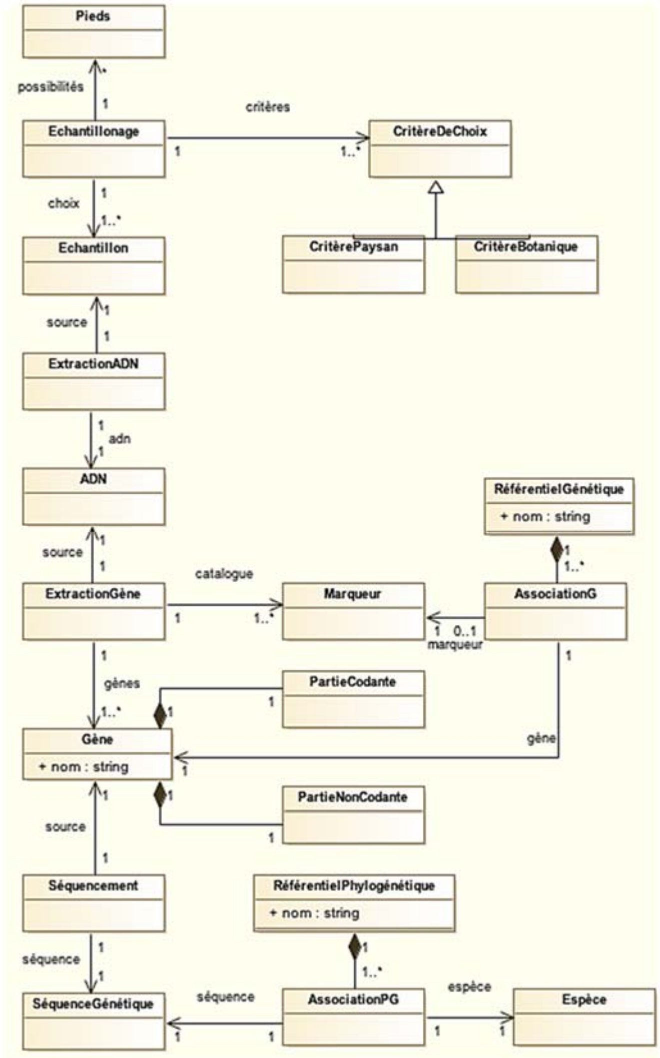

***Figure 5**. The point of view of the geneticist*

This schema represents a process going from sampling plants in the field up to sequencing, identifying the sources of information necessary at each stage (the references for the genetic markers, the species identification, etc.). In this project, the comparison with the points of view of the botanists and biochemists revealed an interesting debate on the relationships among the categories built by the different disciplines: the morphotypes for similar plants, genotypes for similar parts of the genomes, chemotypes for similar organic compositions, and the notion of species. Of course, the notion of similarity is itself different and questionable in each domain and there is no reason to have the various types corresponding to one another, making the very notion of species questionable.

Collective animation

The collective animation consists in deploying the previous approaches in working groups of experts or stakeholders. It can be carried out around a shared schema as illustrated in the figure 6 with drawings or using post-it.

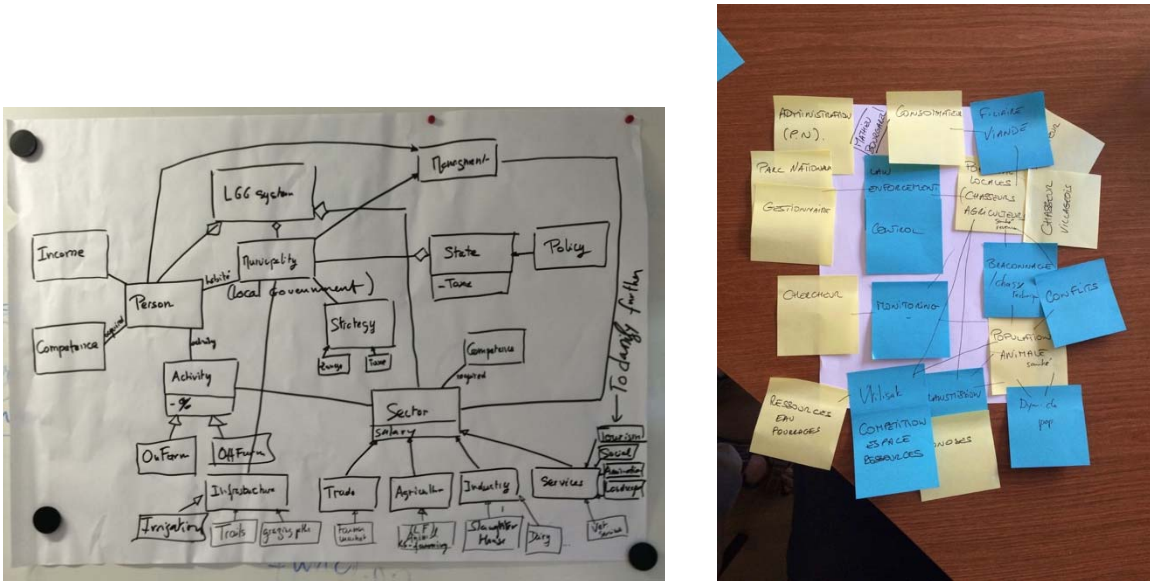

Figure 6. *Brainstorming around breeding or wild fauna management using various supports*

Validation

The validation of conceptual models raises specific issues that are different from the problem of the validation of quantitative models. For the later, the comparison of the model results with measured quantities on the modeled system has been well formalized. For the conceptual model, it is more problematic. We propose three possible and complementary tracks:

1. Restitution of the obtained schemas to interviewed people or groups;
2. Application to case studies;
3. Simulation.

In the case of interviews and collective, the first proposition is compulsory. The risk is the lack of criteria of completion, possibly inducing an endless process. It is particularly the case if one introduce new actors within the process. The same problematic has been identified with technical drawings in industrial engineering. In fact, a conceptual model can be considered as analogous to technical drawings but in larger disciplinary domains.

The application to case studies consists in selecting one or several descriptions of relevant case studies. These descriptions are texts that can be existing (like monographies, papers, etc.), or can be built from knowledgeable actors. The idea is to account the integrality of the text using the concepts mentioned in the conceptual model, i.e. to put each word or group of words from the text within one of the proposed boxes. This work can result in revising the conceptual model because some words do not enter or not exactly corresponds to the proposed concepts, or some concepts are never used. This validation technics is described in (Provitolo, Müller, and Dubos-Paillard 2009).

Finally, a conceptual model can be the starting point of a complete modeling process up to a running simulation. The advantage of this approach is a double requirement:

- A requirement of precision because the description must be sufficiently complete to be able to explain all the dynamics of the described system. In particular, the conceptual model must be completed with the description of the activities and processes. The conceptual model enumerates what are the processes and activities. We still explain how

- they proceed using additional formalisms (equations, dynamical systems, activity diagram, etc.).
- A requirement of validity by comparing the temporal series produced by the simulation with the actual temporal series observed on the modeled system. Very often, one use a part of the observed temporal series to calibrate the parameters of the model (i.e. to adjust the parameters to reproduce the same series), and another part to validate the model (i.e. to compare the simulated series with the observed ones, (Hervé et al. 2013)).

What the conceptual model is to the technical drawings, the simulation model is to the industrial mockup. However, our approach is applicable to a much wider domain up to the mockup of or virtual socio-ecosystem.

Articulating the points of view

In the case of the livestock, four perspectives where chosen and worked on: the social point of view for the role of livestock on social live (social roles, statutes, access to knowledge and competences, etc.), the production point of view with the technical and economical accounts of livestock and its byproducts (wool, milk, etc.), the local development point of view with the role of livestock within a variety of sectors promoted by the local authorities, and the eco-systemic point of view with the positive and negative interactions of the livestock with the natural resources (water quality, biodiversity, nutrients processes and management, air quality, etc.). These perspectives were elaborated by working groups on two sessions: one in April 2016 in Montpellier (France) and one in Saskatoon (Canada) in July 2016.

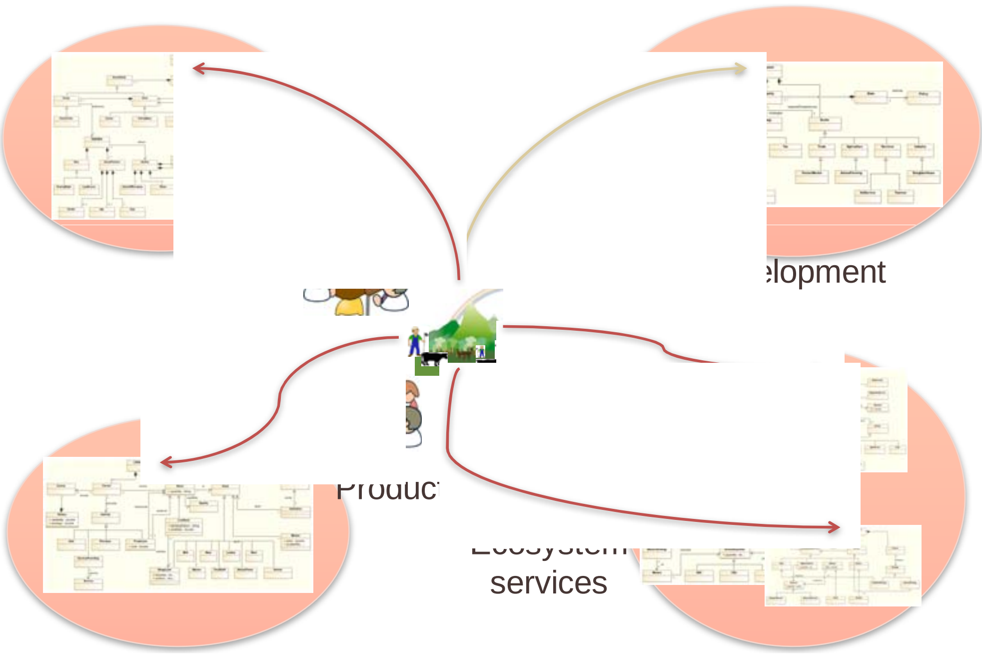

***Figure 7**. The conceptual models from different perspectives*

Each conceptual model has been developed completely independently from one another. But, of course, some words or some concepts appear to be the same, or of the same nature. The next consists in proposing to introduce the discussion on the possible relations between these concepts. For example, concepts related to pieces of land appeared in all conceptual models but with different accounts (see figure 8.) Let's use the concept of landscape as a pivot concept to designate the extent of the eco-system analyzed in different ways depending on the point of view (figure 9):

- From the social perspective, the landscape is seen as a superposition of pieces of land appropriated by different group of actors: the fields by the farmers, the forest by the forest administration, the watershed from the water user association point of view, a field potentially having a part of forest and being situated in a given watershed.
- From the production perspective, the landscape is decomposed into parts having different attributes in terms of available biomass and floristic composition with respect to the productivity of livestock and pathways management.
- From the local development perspective, the landscape is analyzed in terms of zoning, then potential land uses, and its role to favor or not a sector of activity.
- From the eco-systemic perspective, the land is analyzed in habitats for the land cover, and in hydrological components regarding water flow behavior and pollutant diffusion. By the way, the hydrological components are superposed to the habitats, because the fields can themselves be water containers.

As a whole, the landscape appears as an intricate set of superposed mosaics that depends on a variety of concerns and therefore submitted to a variety of decisions and processes interacting with one another. Consequently, it becomes possible to assess what could be the impact of a decision from one perspective onto all the other perspectives.

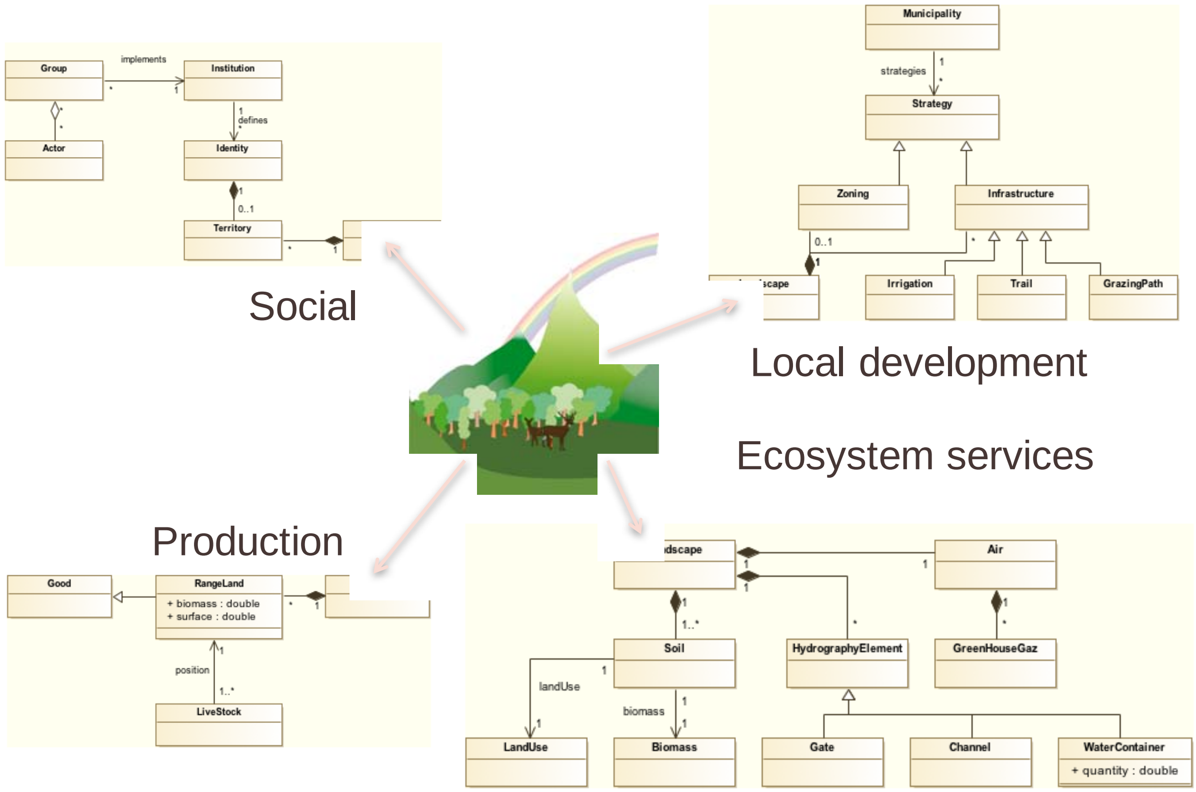

***Figure 8**. The landscape seen from the various perspectives*

Document, standardize and share information on lessons learnt, within the Global Agenda for Sustainable Livestock

(output 1 of the Action Network 2: restoring value to Grasslands)

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GASL

The primary objective of the Global Agenda for Sustainable Livestock is to maintain, restore and enhance environmental and economic value of grasslands, while promoting their social and cultural functions globally. Grasslands are ecosystems generating multiple services. Worldwide, great efforts within field projects to implement ideas on how to improve grassland/pasture management to deliver multiple outcomes are deployed. Much literature is available, but no "library/inventory" with an overview on the most relevant key elements considered/implemented/achieved in different projects/pilot sites.

Within Action Network 2, it was therefore decided at the Workshop in Montpellier 2014 to build an Internet friendly framework, including standardized information on lessons learnt. This information on sustainable grassland management and its multiple outcomes shall include topics as: land tenure, institutional arrangements, sustainability dimensions, etc.

In order to facilitate the standardization of information, a matrix has been elaborated to fill in the information on pilotsites.

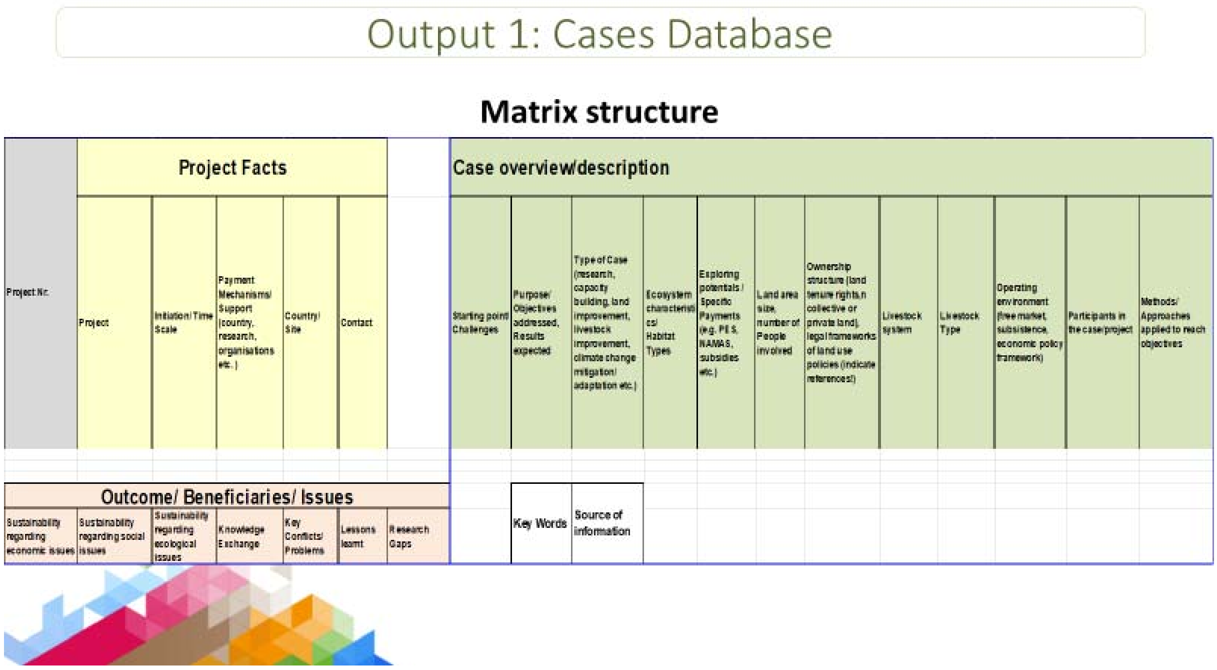


Fig 1. *Extracts of the structure of the matrix (framework) on pilotsites*

The aim of the database is to allow fast dissemination of relevant information regarding restoring value to grassland, facilitate exchange of experiences, catalyze practice change and become a "virtual knowledge center network". In the near future, it should be possible to access relevant information in this database of pilot sites (cases) from all over the world, published on the Global Agenda Web Site. Future targeted groups will be project leaders, researchers, policy makers, NGO's and interested persons. Big effort will have to be put in the dissemination of collected information and its multiplication through the GASL information site.

The framework has been adapted to a WEB friendly format by FAO.

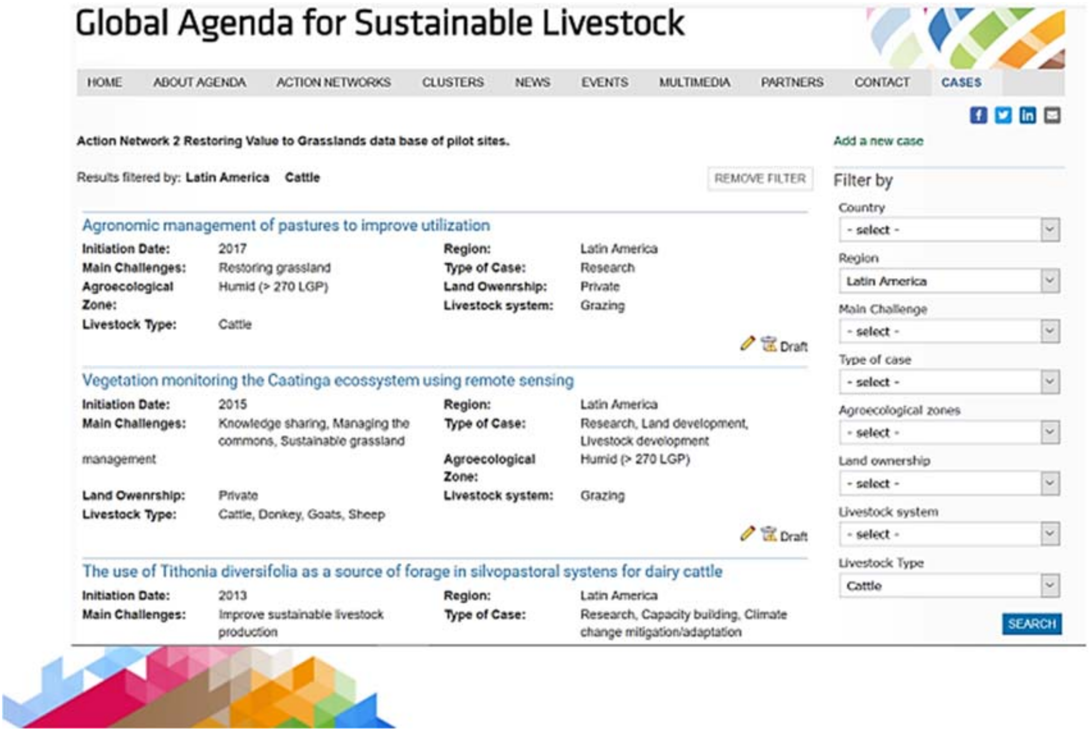
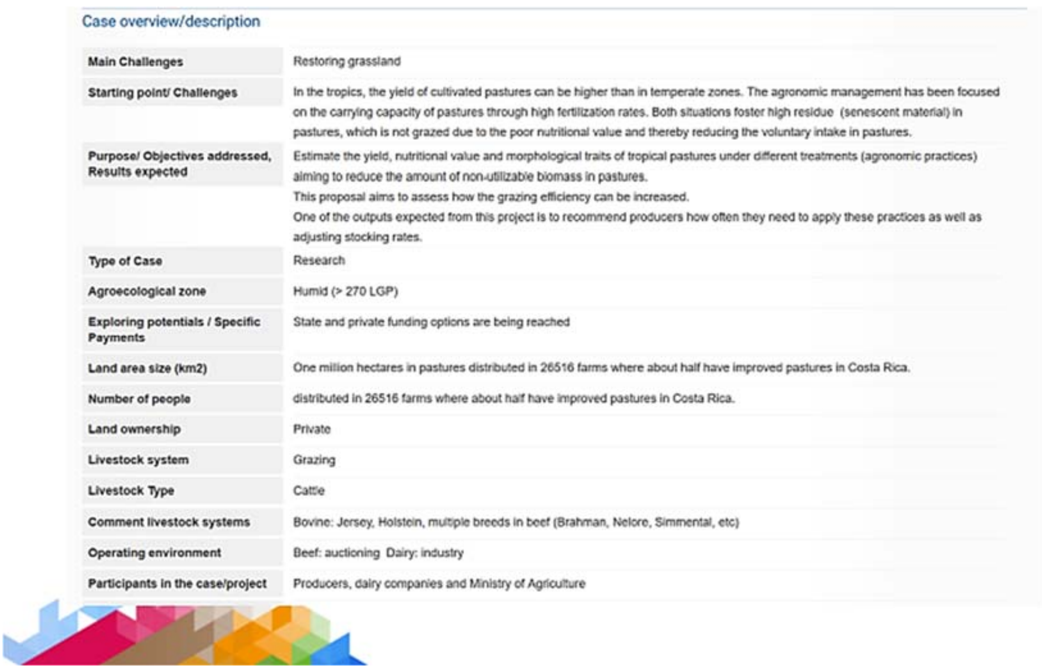


Fig 2*. Within the database, information can be filtered by different subjects*

Details on cases are given by clicking on the project. The data base gives detailed information on project facts, case overview/description as well as on outcome/beneficiaries' issues.



Case overview/description

Main Challenges	Restoring grassland
Starting point/ Challenges	In the tropics, the yield of cultivated pastures can be higher than in temperate zones. The agronomic management has been focused on the carrying capacity of pastures through high fertilization rates. Both situations foster high residue (senescent material) in pastures, which is not grazed due to the poor nutritional value and thereby reducing the voluntary intake in pastures.
Purpose/ Objectives addressed, Results expected	Estimate the yield, nutritional value and morphological traits of tropical pastures under different treatments (agronomic practices) aiming to reduce the amount of non-utilizable biomass in pastures. This proposal aims to assess how the grazing efficiency can be increased. One of the outputs expected from this project is to recommend producers how often they need to apply these practices as well as adjusting stocking rates.
Type of Case	Research
Agroecological zone	Humid (> 270 LGP)
Exploring potentials / Specific Payments	State and private funding options are being reached
Land area size (km2)	One million hectares in pastures distributed in 26516 farms where about half have improved pastures in Costa Rica.
Number of people	distributed in 26516 farms where about half have improved pastures in Costa Rica.
Land ownership	Private
Livestock system	Grazing
Livestock Type	Cattle
Comment livestock systems	Bovine: Jersey, Holstein, multiple breeds in beef (Brahman, Nelore, Simmental, etc)
Operating environment	Beef: auctioning Dairy: industry
Participants in the case/project	Producers, dairy companies and Ministry of Agriculture

Fig 3*. Detailed information on case overview/description according to the information given in the matrix*

Outcome/ Beneficiaries/ Issues

Sustainability regarding economic issues	Higher utilization of pastures may allow reduce the use of feedstuff (imported in our conditions)
Sustainability regarding social issues	Small producers are more sensitive to increases in commodities as they own less animals than bigger operations.
Sustainability regarding ecological issues	Carbon footprint lower in farms that rely more on pastures.
Knowledge Exchange	Through extension talks with producers and technicians
Key Conflicts / Problems	Difficult to monitor state of pastures is a general issue on farms.
Lessons learnt	Ongoing project.
Research Gaps	funding
Keywords	Tropical pastures, senescent material, utilization.
Source of information	https://luisvillalobosblog.wordpress.com/acerca-de/

The database has multiple utilities. Results can be filtered and allow extracts by region, type of livestock, type of landscape and of intervention e.g.

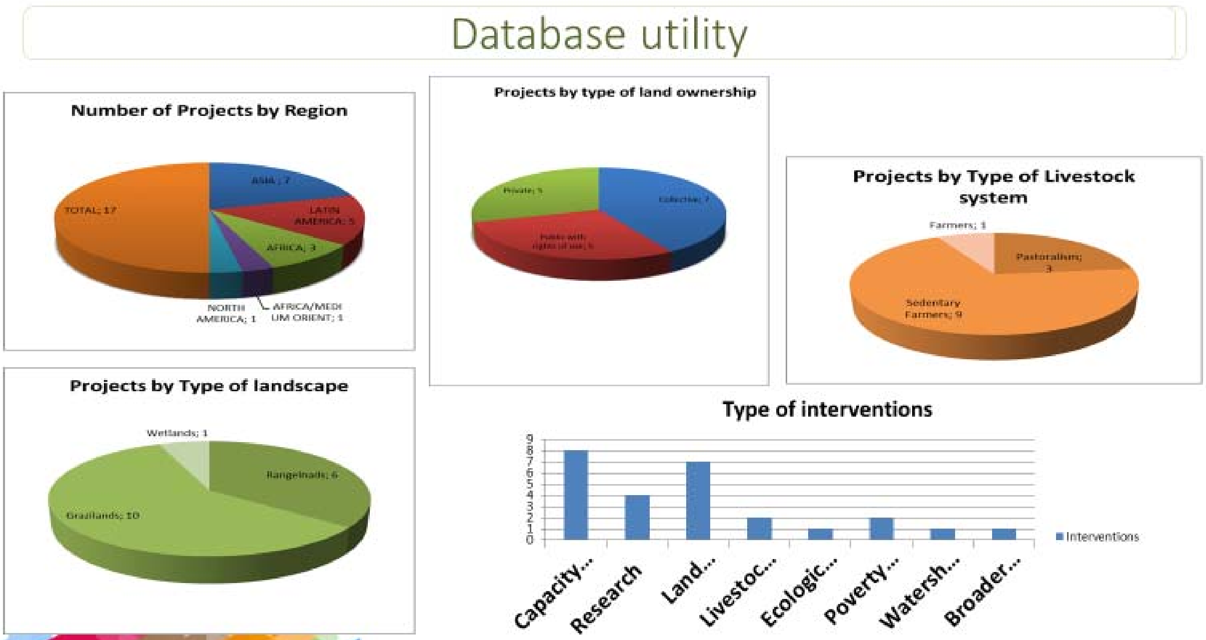


Fig 5. *Possibilities of extractions for various purposes*

Up till now, 28 cases have been sent in and added to the database. Some more have already been promised. It is a continuous search for new cases, in all stakeholder meetings, in specific working groups, at every event on grasslands as well as through literature and hopefully the GASL homepage will invite project leaders to add their cases to this database.